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ABSTRACT

This paper argues that the most important role the intelligent videodisc can fulfill is to provide a mechanism for effectively integrating testing and instruction. This integration will produce at least four important benefits: (1) increased learning by the student, (2) more interesting instructional materials, (3) gains in the efficiency of testing, and (4) less clerical work for the instructor. The success of videodiscs in instruction will depend largely on how well they maintain student motivation by providing attainable goals, frequent feedback, appropriate difficulty, and minimized failure, and whether they allow for such individual differences as attitudes and interests, time required for learning, student's knowledge base, and generalized ability. Difficulties in implementing a proposed diagnostic-prescriptive model and steps toward improving the chances for success in implementing the model include the need for large item pools and infinite numbers of different tests, scoring problems, burdensome recordkeeping, and complexity of the prescriptions. Some challenges to the advocacy of this model and its implementation are discussed. (CHC)

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INTEGRATING TESTING AND INSTRUCTION USING THE VIDEODISC

by

Michael D. Hiscox

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INTEGRATING TESTING AND INSTRUCTION USING THE VIDEODISC

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ABSTRACT

Effective instruction must have testing as an integral component. Only when an efficient and appropriate measure of the student's progress through a learning activity is available can the instruction be tailored to meet that student's needs. Earlier attempts to integrate testing and instruction were often ineffective. The advent of the intelligent videodisc system may permit instructional designers to overcome earlier difficulties to create materials in which testing is not a separate, after-the-fact component but instead is an inseparable part of the instructional process. This paper adopts the premise that the most important role the intelligent videodisc can fulfill is to provide the mechanism for effectively integrating testing and instruction.

INTRODUCTION

Educators and trainers are rapidly becoming aware of the potential benefits and, one would hope, difficulties that can accrue from the use of the videodisc as an instructional tool. Certainly there are any number of tasks which the videodisc can do as well as or better than currently available techniques. And when consideration is broadened to include the "intelligent" videodisc (a videodisc player interfaced to a computer which can control the player's functions), the possibilities are impressive.

One area in which the intelligent videodisc may be able to make a considerable contribution is in the integration of testing and instruction. This integration will produce at least four important benefits:

1. Increased learning by the student;
2. More interesting instructional materials;
3. Gains in the efficiency of testing;
4. Less clerical work for the instructor.

It is this author's opinion that the integration of testing and instruction using the intelligent videodisc is a feasible goal, and one worthy of the time and effort of instructional designers. This paper will discuss what the intelligent videodisc can do to enhance this integration and why such integration is critical to an improved educational process.

THE LEARNING PROCESS

In order to understand the benefits the videodisc can bring to testing and instruction, a short discussion of the learning process is in order. (It should be noted that the points discussed below are held to be true by a substantial portion of current learning theorists; some areas of contention still exist, however.)

Learning occurs in different ways for different learners, and instructional materials should take these differences into account. There are two general characteristics for which all learning materials must allow: student motivation and individual differences. The success of the videodisc in instruction will depend largely on how well the disc systems and software (1) maintain student motivation and (2) allow for individual differences. A brief discussion of these two characteristics follows.

Motivation

It is apparent that the learning a student obtains is directly related to that student's motivation to learn. All other things being equal, the higher the motivation, the greater the amount of learning. Maintaining a high level of motivation depends on four major components, as follows:

Attainable Goals. The learner must know what is expected—i.e., what the learning goals and objectives are. Further, the student must consider the goals and objectives to be attainable. Unrealistic goals will reduce student motivation.

Frequent Feedback. In order to maintain motivation, the learner must be frequently apprised of the progress being made on the lesson. Praise for correct performance and assistance with incorrect performance should be given often.

Appropriate Difficulty. Learning something requires the integration of the new information with the student's existing knowledge. If the concepts under study are too difficult, they cannot be appropriately integrated. When this happens, the student will experience considerable frustration, and will lose motivation.

Minimization of Failures. Many learning theorists feel that trial and error learning is not a very effective technique. Rather, the motivation of learners is higher when they are guided through materials in a way that minimizes failures.

Individual Differences

No two people learn in exactly the same way. It is generally agreed that instruction will be more effective when it is tailored to allow for the indvidual differences of students in these four major areas:

Attitudes and Interests. Learning will be more effective when addressed to an area of interest of the student and in accord with the student's attitudes. Students simply pay more attention to learning activities which interest them and to which they can relate.

Time Required for Learning. It is widely believed that the differences among learners is not so much in their **ability** to learn, but rather in the **time** required to learn a given concept. Any instructional system that allows students all the time necessary to learn a concept, while avoiding wasting time after the concept is learned, will enhance learning.

Student's Knowledge Base. As mentioned above, learning requires the integration of any new concept into an existing base of knowledge; a concept which is not successfully integrated is soon lost. No two students bring the same knowledge base to a learning task. Unless allowances for this are made by the instructional system, some of the students will not learn effectively.

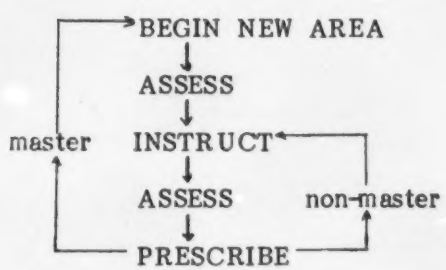
Generalizing Ability. It is impossible to teach a student all of the individual cases in which a concept might be useful. Instead, the student must be taught to generalize from the specific instance to the broad range of applications. Only when this ability to generalize is present can the student be said to have really learned a concept. But since students differ in their ability to generalize, the instructional materials must allow for these differences.

Perhaps the reader can see where this discussion is leading. The eight conditions listed above can only be met when the instructional system is designed to handle large amounts of different material, vary its presentations in response to existing and developing student interests and abilities, measure student progress and provide feedback, and allow as much time as required for the student to learn a given concept. An intelligent videodisc system is one of the few delivery systems currently conceived with the requisite characteristics. But we our ahead of ourselves....

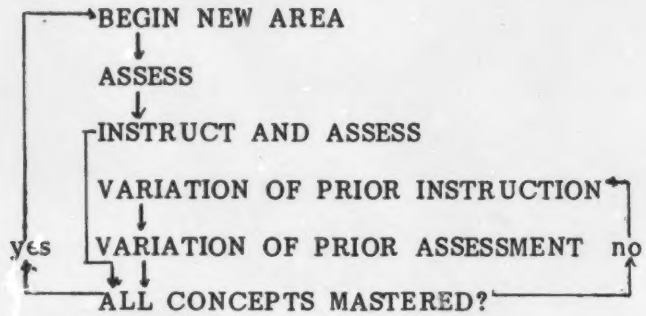
THE DIAGNOSTIC-PRESCRIPTIVE MODEL

Learning theorists have developed a common sense sort of model that addresses the concerns expressed above. It takes various forms and goes by various names—one of the most common being the Diagnostic-Prescriptive Model. The description which follows is a considerable simplification, but for our purposes it is the concept and not the technicalities that matter. Reduced to its simplest elements, the model is merely a way of using the results from an assessment of the student's knowledge, interests,and/or abilities to affect the instruction which follows. The process is cyclic; frequent assessments are performed and used to prescibe the instruction presented next. The student leaves the cycle when an assessment shows that all of the goals of the lesson have been met. The student then proceeds to a new area.

The interdependency of instruction and assessment is shown by the following diagram:



The process shown above is not the optimum form for the model, although it still has much to offer most instructional designers. But in the listing above, assessment and instruction are separated. This inadvertently implies that the two are distinct processes. In its ultimate manifestation, the diagnostic-prescriptive model does not separate testing and instruction; rather, assessment activities are an ongoing part of the instruction. Such a form for the model can be represented as follows:



The second figure attempts to show that there is constant, integrated assessment taking place during any instructional sequence. The testing is not separated, but rather is inserted throughout the instruction in order to continuously direct the student down the most efficient and effective learning path. A learning system which is predicated on this model would be very effective indeed, since it takes full advantage of many of the processes which have been shown to increase student motivation and account for individual differences (e.g., frequent feedback, minimization of failures, adequate time for learning).

Unfortunately, it is easier to describe the diagnostic-prescriptive model than it is to implement it. Very few learning systems faithfully follow the first version of the model, and it is likely that no system faithfully follows the second, except for very brief, prototype learning activities. Thus, in spite of the tremendous benefits the fully integrated diagnostic-prescriptive model could bring to an instructional setting, it can rarely be implemented effectively.

Difficulties in Implementing the Model

It is appropriate to outline the difficulties faced in implementing the learning model described above in order to determine which of them can be overcome and which resist solution. The role of the intelligent videodisc in solving these problems will then become the focus of the remainder of this paper.

The diagnostic-prescriptive models described above require much more testing than is normally available in standard instructional materials. The creation of effective assessment items is very difficult, and thus large pools of good test items are relatively rare. Those that exist are often jealously guarded. The number of item pools readily available for use is too small to meet the requirements of extensive, ongoing assessment required by the diagnostic-prescriptive model.

The full implementation of the model requires an essentially infinite number of "tests". Since each student's next test question is dependent upon the path taken through the learning material and since there would be a tremendous number of different paths (in order to match the learner's experience, background, ability and interest), every student's testing would likely be different. It is not possible for the instructor, who is used to handling one test per instructional unit, to cope with the multitude of very short, frequently administered tests required by the diagnostic-prescriptive model.

Even if there were a way to work with the large number of tests required, there would be no efficient way to manually score the tests and return them to the students quickly enough to serve as the basis for determining the next instructional approach. Remember, the diagnostic-prescriptive model requires the full integration of testing and instruction; if done correctly, the two are inseparable. There is no way that the student's instruction could be delayed while the two- or three-item "test" given to verify learning of a single concept is scored.

Further, even if one were able to create, administer and score the required "tests", recordkeeping would still be a critical problem. Each student will likely be at a different point in the learning process, and each is proceeding along a different path toward mastery of the area. Any instructor who wished to follow the progress of the students would be faced with an incredibly complex task. A single lesson might reasonably have 20 different skills to be learned; each skill would have, at the very least, a mastery/nonmastery record to be maintained. If the instructor has 100 students, that instructor would have 2,000 pieces of information to record for a single lesson. Worse yet, the status of these records would change almost by the minute!

There is yet another critical problem, that of the "prescription". Since the model requires that each assessment be used to prescribe the next learning activity, the very large number of assessments requires an equally large number of prescriptions. And since the assessments are very precise, generalized prescriptions such as are frequently used (e.g., read Chapter 3 of the supplemental text, ask your teacher for help) would be of no value. No instructor would be able to provide students with all the specific prescriptions needed in a timely manner.

This is a sizable list of problems, and one hesitates to make the situation worse. But there is a tremendous problem in the discrepancy between the precise instructional sequences required by the diagnostic-prescriptive model and the relatively unfocused manner in which instruction is usually carried out. Some have made the claim that many instructors, if interrupted in the middle of their teaching, could not offer a precise explanation of the instructional objective they hoped to attain. Our skills in defining instructional tasks, developing precise objectives, creating targeted instructional materials and producing effective assessment instruments are not currently up to the task of a full implementation of the diagnostic-prescriptive model.

Steps Toward Solutions

The paragraphs above present a lengthy and perhaps insurmountable list of problems which prevent successful implementation of the diagnostic-prescriptive model. Solutions to all of these impediments may not be possible, but there are things which can be done to increase the chances of success.

The diagnostic-prescriptive model requires the student to maintain motivation throughout the learning sequence. Dull and repetitive instruction cannot be allowed. In particular, a student who fails to grasp the concept after some initial instruction should not be retaught using the same, previously unsuccessful method. Before we attack any of the problems mentioned above, we must resolve to provide more varied, more versatile types of instruction to the learner.

We must also do better at providing the test response modes that are most suitable for the skills being taught. Whereas a multiple-choice examination may have served to summarize a student's accomplishments during the year, our model requires assessment by the minute. We will want to assess a considerable number of skills which may not lend themselves to measurement by a multiple-choice format. Multiple-choice questions should not be ignored, for they are capable of some very sophisticated assessments when constructed correctly. But educational testing has built up a dependence on this single format, and that format will not always be compatible with the proposed model.

We must also be prepared to do everything right. That may seem like a maxim not worth considering, but the fact is that most educational materials have "bugs" in them. Our materials, particularly those that attempt any idiosyncratic (i.e., branched) sort of instruction, often have mistakes. Even those that avoid mistakes in the material often have mistakes in their usage requirements; that is, they take away flexibility, they don't fit the constraints of the learning environment, or so on. It will be extremely difficult to implement the diagnostic-prescriptive model, even with the best of materials. Care must be taken to avoid mistakes in materials that will confound our implementation.

Finally, we can help ourselves by choosing for our effort a subject area with the proper structure. Certain subjects such as math computation and electronics have concrete, readily identifiable skills and concepts which must be mastered. In general, a student either can or cannot correctly apply Ohm's Law. Further, if a student cannot apply the law, the steps for remediation are reasonably clear cut. This situation contrasts with subject areas such as interpersonal relationships or reading comprehension, where the learning objectives (such as "Be a good leader" or "State the main idea of a passage") are often accumulations of other skills. Unlike the mastery/nonmastery situation with Ohm's Law, interpersonal skills and reading comprehension are not yes/no types of subjects. Our diagnostic- prescriptive model will be much more effective if we apply it to subjects with more independent skills. (On the other hand, subjects such as spelling and vocabulary have skills which are too independent, i.e., knowing the synonym for one word does not provide much information about the ability to identify the synonym for the next word. As you can see, there is a thin line between properly independent skills and those which are too specific. But since we will encounter many problems in fully implementing the diagnostic-prescriptive model, we should make things as easy as possible at the beginning by choosing a viable subject area.)

Having "put our house in order" by becoming alert to the basic requirements we must meet, we are prepared to attempt the solution of the difficult problems that work against successful implementation of the diagnostic-prescriptive model.

THE ROLE OF THE INTELLIGENT VIDEODISC

Some readers are by now way ahead of this narrative. At the mention of a problem such as, "It's too burdensome to keep all those records" or, "We must be able to have very large numbers of items available," one quickly thinks "This may have been a problem in the past, but now we have microcomputers and videodiscs and other technological solutions to all these problems." And there is a fair chance that such a thought would be correct.

There is no question that some of the time-consuming, repetitive tasks necessitated by the diagnostic-prescriptive model would be child's play for a computer-controlled videodisc, even one incorporating a small microcomputer. Let's examine the problems mentioned earlier to determine which are solved through use of intelligent videodisc hardware.

1. The NEED FOR LARGE ITEM POOLS can be helped by both the computer and the videodisc. In cases where the types of test items follow a standard format, the computer can use item generation programs to produce literally millions of different items. When that is not possible, the huge storage capacity and quick access time of the videodisc allow very large item pools to be readily accessible. (There are still difficulties with the generation and distribution of item pools, but use of the videodisc would certainly help make widespread creation and use of item pools more appealing.)

2. The INFINITE NUMBER OF DIFFERENT TESTS required is also solvable through use of the computer. Whether the test items are stored on a videodisc, stored in the computer's mass storage, or generated by the computer as needed, the computer can select and arrange the items in the optimum manner, and can then present such a test to the student with no noticeable delay. The test items can be presented with variations in item difficulty or item content; in either case, the student would be attempting test items which are as close as possible to the level of difficulty most appropriate for his or her own level of attainment. (This contrasts with current testing methods, where as many as three out of every four items add no information to the assessment because they are obviously either too easy or too hard for the student.)

3. The SCORING PROBLEMS mentioned earlier are greatly mitigated by the computer. As each item is presented, the computer can refer to the correct, close, and expected incorrect answers previously provided by the instructional designer. Immediately upon the student's response to a question, the computer "knows" whether the student answered correctly. Students can be made aware instantly of their success; as previously noted, this immediate feedback is very valuable for maintaining motivation.

4. The BURDENSOME RECORDKEEPING required by the model is no problem for the computer. Within the constraints of their memory and storage capabilities, computers have no difficulty recording where they are in an instructional sequence and where they have been. They are also facile at manipulating and aggregating such data to produce any combination of information required by the instructor or student.

5. COMPLEXITY OF THE PRESCRIPTIONS, a major problem with manual systems, is readily handled by the computer and the videodisc. As soon as the computer has determined the student's success in learning a concept, as measured by the test items, it can select and present the optimum next segment of instruction. This material would be remedial in the case of a nonmaster or would introduce a new area to the student who had demonstrated mastery. It might also provide further testing if there were some doubt about the student's mastery status. All of this activity would be essentially transparent to the student. The delivery system would take care of all the selection and presentation activities.

A substantial dent has been made in the list of problems which prevented appropriate implementation of our desired diagnostic-prescriptive model. In the intelligent videodisc system we have uncovered at least some of the capabilities of an instructional library, a teacher, a test administrator, a scoring machine, a test constructor, a test reviewer, a recordkeeper, and a curriculum specialist. The considerable advantages of the diagnostic-prescriptive model are now within reach.

CAVEATS, CAVEATS, CAVEATS

This paper has, to this point, taken a positive point of view about the benefits of the diagnostic-prescriptive model and the role the intelligent videodisc can play in implementing that model. Both points of view are warranted; the diagnostic-prescriptive model could provide tremendous gains in instructional efficiency, and the intelligent videodisc system is a way that this model, which is not currently used except in very limited situations, can become practical. But such advocacy can be challenged for a number of reasons, and many prudent people feel that even with the assistance of the intelligent videodisc, the complete integration of testing and instruction cannot be achieved. Several examples of such challenges are given in the following paragraphs.

Very often, a piece of technology comes along that is able to solve a given set of problems, but unfortunately that technology arrives before all of its necessary supporting pieces are ready. The videodisc is now a relatively proven technology—50,000 test items **could** be stored on a single videodisc. Yet the associated technology of the display mechanism required (the monitor or television set) does not allow full advantage to be taken of the videodisc capabilities. The monitors currently available (at "reasonable" cost) cannot display more than a few hundred readable characters on a screen at any one time. This is not sufficient for presenting instructional frames or many test items. It will be several years before the full capacity of the videodisc can be used in instruction, simply because it will take that long for display screen technology to "catch up" with videodisc technology.

A similar problem is encountered with the question of audio information on videodisc. At the present time, one minute of audio requires 1,800 frames of videodisc information, regardless of whether it accompanies 1 or 1,800 frames of video. Audio information is important to most instructional materials, but it is currently too wasteful to use the disc to present audio to accompany single frames. Compressed audio (providing, for example, 30 seconds of audio with a single video frame) is not yet available, and solutions involving the storage of audio on magnetic media read by a computer are inelegant and costly. Once again, our basic concept is in advance of the required peripherals.

If the diagnostic-prescriptive model were to be implemented for a number of educational or training subjects, the complexity of the effort would boggle the minds of most instructional developers. This doesn't indicate shortcomings in the minds of the developers; rather it indicates an incredible complexity brought about by the non-linear, branched, and completely individualized nature of the material and testing presented. For example, to ask a student just three test questions tailored to an appropriate level of attainment, with feedback and an appropriate instructional frame following each answer, would require over twenty frames (if there were a correct answer frame or one of three different instructional frames presented after each question). Four questions would require nearly fifty frames, five questions would require nearly one hundred frames. The complexity makes this sort of instructional sequencing impossible with conventional flowcharts and planning. Only when sophisticated computerized systems for keeping track of the branching and testing are widely available will it be possible to develop an extensive array of learning materials in which the videodisc can truly integrate testing and instruction.

For better or worse, videodiscs are made from high quality videotapes. The production of this high quality videotape is a complicated process which can be performed by relatively few specialized organizations. Because of the cost of the equipment involved, these organizations must charge fairly high rates. This combines with the high cost of instructional designers, course writers, and computer programmers to make the instructional videodisc a relatively expensive undertaking. It is, perhaps, too expensive. A videodisc which provides twenty hours of instruction to a student costs in the neighborhood (a very broad neighborhood) of $50,000 to design and produce. A public school student spends over 2,100 days in school during 12 years of instruction. Providing sufficient videodiscs to cover even half of that time would require over 300 discs, which translates to an expenditure of over **fifteen million dollars.** In actual fact, evaluation and implementation costs would make the figure much higher.

It is unlikely that many people would spend this kind of money, even on something that was guaranteed to work. It is even less likely that that level of money would be spent on something that might not work. But at the moment, there are no evaluation data to support the contention that intelligent videodisc systems could make a significant contribution to education at the instructional level. The evaluation of technology-based instructional programs is possible, but only when it is done in a very rigorous and insightful manner. So many things (e.g., the design, the hardware, the attitudes of users, the cost) have to be close to perfect before a successful implementation occurs that most technology- based instructional systems fail to achieve their goals. Thus, until a comprehensive evaluation proves the merit of a system such as the intelligent videodisc, potential users would be wise to proceed with extreme caution. But since the system cannot be effectively evaluated without systems and users, we have a difficult dilemma.

A related problem is that education puts less money, as a percent of its revenues, into research and development than any other group. The automobile, steel, rubber, food processing, clothing, and even construction industries put a larger proportion of their revenue into R&D activities than does education, twenty times as much in some cases. Thus, while the diagnostic-prescriptive model and the intelligent videodisc have much to offer education, it is unlikely that the funding necessary to research and develop quality systems will be available in the foreseeable future.

Education is also handicapped because, unlike most other groups, it does not operate on a cost-benefit basis. While most other businesses and industries will readily invest five dollars in a training system that will permit a worker to produce ten dollars' worth more output, education does not. The value of the product of the educational system, the educated person, cannot be assigned a dollar value. It is impossible to calculate the costs associated with students who do not develop to their full potential. Thus education has no real way of knowing if the expenditures that would be necessary to implement integrated testing and instruction using an intelligent videodisc would be worthwhile. (Fortunately, training programs in business and industry are considered on a cost-benefit basis. Developers of these programs will, hopefully, begin rigorous plans of investigation into the value of videodisc-based diagnostic-prescriptive instructional systems. Further, it is hoped that results of such investigations will be made available to the general education and training public.)

SUMMARY

This paper ends without a conclusion. The author has attempted to make the point that the integration of testing and instruction through use of the diagnostic-prescriptive model would greatly improve the learning process. The paper noted several important characteristics for learning and showed how the diagnostic-prescriptive model helps guarantee that those characteristics would be present. The paper then discussed the difficulties in implementing this desirable model, and the intelligent videodisc system was proposed as the means of mitigating those problems. But the intelligent videodisc itself is not without problems, some of which were brought forth at the close of the paper.

So where do we stand now?

Perhaps only a cliche such as "Only time will tell" or "What will be, will be" can come close to summarizing the situation. There is no question that the integration of testing and instruction is an important goal. And there is no question that the intelligent videodisc could facilitate that integration. But beyond these two givens, there are numerous unknown, and perhaps unknowable, considerations which make it impossible either to fully advocate work to implement videodisc-based instruction using the diagnostic-prescriptive model, or to discourage such work as being impractical.

The importance of careful, empirical evaluation cannot be overemphasized. One would hope that the resources devoted to the study of intelligent videodisc systems and their use in integrating testing and instruction rises above the very modest amount typically expended by educators and trainers for evaluation. The dollars spent on proving or disproving the value of intelligent videodisc systems should be viewed as nothing less than an investment—an investment that, if made properly, will return significant dividends.

The wise person will be one who remains abreast of developments and works to gain an insight into how such developments can be used to advantage. But such a wise person will not place him or herself in an untenable position through the unquestioned support of a potentially impractical technology. One must strike the perfect balance of forward thinking and measured restraint.

This advice is (a) obvious, (b) trite, and (c) about all the guidance that can be offered at this time. As you proceed to consider the role of the intelligent videodisc in integrating testing and instruction, you are weighing an effort with major problems and considerable complexity against an outcome that has much potential to produce tremendous benefits. It behooves persons responsible for planning the future of training and instruction to gather as much information as possible in order to make certain that those weighings are accurate.